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# ASPECTS OF THE THEORY OF DISCOUNTING

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Many theoretical and practical problems, in planning for the economic development of underdeveloped countries (the field in which the writer is primarily interested), are similar to those facing executives who must select worthwhile investment projects for their corporations. A difficulty shared in common is that of assessing expenditure and revenue flows occurring at different points in time. The method universally applied, even, apparently, in the Soviet Union, is to discount these flows to the present by some factor, usually a rate of interest. When examining the criteria put forward by economists, for project selection, the impression is gained that discounting procedures are applied mechanically, with little thought given to the reasons for using the discount rate or what rate of discount to apply.[1]

This paper will first attempt to demonstrate that interest rates do not necessarily measure people's time preferences with regard to the use of income, and that there is, accordingly, no justification for the automatic use of interest rates to discount expenditure/revenue flows. It will be argued that while interest rates have little or no effect on the consumption-versus-saving

*The author gratefully acknowledges the criticisms of his colleague, Mr. Ken Smith, and of Professor Michael Montias of Yale University, but hastens to absolve them of any responsibility for the views expressed.

[1]A notable exception to this stricture is Otto Eckstein, who, in his Water Resource Development - The Economics of Project Evaluation (Harvard University Press, Cambridge, Mass., 1958), made a valiant and thoughtful effort to ascertain an appropriate interest rate to apply to the discounting of flows in public power projects. His basic assumption, that interest rates reflect time preferences, is questioned here.

decision of individuals, the differential earnings proffered by the alternative forms in which savings can be held will affect the distribution of the savings flow, and it is this latter role that justifies and guides executives in the use of intertemporal discounting procedures.[2]

## CONTRADICTORY VIEWS CONCERNING THE THEORETICAL JUSTIFICATION FOR DISCOUNTING

There are two main and unreconciled views concerning the reasons for discounting intertemporal accounting flows, the most explicit proponents being Irving Fisher, on the one hand, and Robert Dorfman, on the other.

Fisher seemed to argue his case in the following way:

> Thus all time preference resolves itself in the end into the preference for comparatively early <u>income</u> over comparatively remote, or deferred, <u>income</u>.[3]

This is because a consumer "prefers the service of milling flour in the present to milling flour in the future because the enjoyment of the resulting bread is available earlier in the one case than in the other".[4] Although many factors enter into the determination of an individual's pattern of intertemporal consumption,[5] it seems that the "representative" person exhibits a myopic impatience and under-

[2]The reader will note that the terms "interest rates" and "earnings" have been used in this sentence as if they were synonomous, which, in fact, they are not. The confusion arises by virtue of the fact that economists traditionally associate saving with the interest rate and ignore other important rewards, such as dividends and capital gains. For convenience we will follow this procedure in the first part of the paper, and will lump together all the inducements to save and call them "interest".

[3]Irving Fisher, <u>The Theory of Interest</u> (The Macmillan Company, New York, 1930; reprinted by Kelley and Millman, New York, 1954), p. 63.

[4]Ibid., p. 64.

[5]Ibid., p. 89.

estimation of his future wants. But impatience is in perpetual conflict with opportunities to invest. Some part of present income can always be exchanged for a higher future income, by saving; and future income can be traded for present income, by borrowing. Any given market rate of interest will be high enough to override some of the impatience of some of the population, and they will lend up to the point where the rate of interest equals the rate of marginal time preference. But that rate of interest will be too low to induce savings from another group, who will supplement current income, by borrowing, until the marginal time preference rate equals the rate of interest.[6] The market rate of interest, then, is an index of a collective assessment of time preference. Because of impatience, future income is worth less to an individual than present income, and the price we pay for present consumption is measured by the increase in income (given by the interest rate) that will occur between now and then. Thus future income can be given a value at $t_o$ by discounting back at the market rate of interest.[7]

However, Professor Dorfman writes:

> Present goods are more valuable than future goods of like kind and number. The validity of this dictum does not depend on time-preference or the perspective underestimation of future wants or any such subjective and perhaps irrational consideration. It depends on

[6] Ibid., pp. 94-98, 250-252, 104. Strictly interpreted, this cleaves the world into two distinct groups; those who borrow and those who save. It cannot account for the third group who save and borrow simultaneously.

[7] If, for instance, one holds a property right by virtue of which he will receive, at the end of one year, the sum of $104, the present value of this right -- if the rate of interest is 4 per cent -- will be $100. (Irving Fisher, The Nature of Capital and Income, The Macmillan Company, New York, 1906, pp. 202-203.) But if the market rate of interest is only an average, it is a meaningless basis for an individual to use in making intertemporal calculations.

> the ability of present rations to finance an accumulation of Meccano sets that will enhance the flow of future rations.[8]

Does not the contradiction lie in more than just the phrase we emphasized? Is this not stating that present income has value because it provides for <u>future</u>, as well as present, wants? Could it be interpreted to mean that future consumption is just as meaningful and desirable as present consumption?[9]

Do either of these views validate the practice of discounting corporate cash flows, or is there some other justification? And, no matter what the justification, how should a corporation select the appropriate discounting rate?

## INDIVIDUAL TIME PREFERENCE AND ITS RELATIONSHIP TO INTEREST RATES

For purposes of this paper, let us entertain the assumption that the prime responsibility of corporate officers is to the stockholders; and therefore any intertemporal measurement of net income flows must somehow reflect the collective time-preference patterns of corporate owners. Putting it another way, savers retain or acquire holdings in a given company since, they believe, income-flow prospects are coordinate with their desired future income-flow patterns. The saver's ultimate selection of a given company is the visible end-result of two essentially complex, but conceptually separable, decisions: (1) the distribution of income between consumption and saving; (2) given the level of saving, its

[8]Robert Dorfman, "Waiting and the Period of Production", <u>Quarterly Journal of Economics</u>, Vol. LXXIII, No. 3, August 1959, p. 359. Emphasis ours. The Meccano sets to which Dorfman refers are the English equivalent of Erector sets.

[9]The reader will note that, if discounting is appropriate under these latter rules, the rate will not be interest but rather some appropriate rate of profit.

distribution among alternative forms.

DECISION I. Out of current and future income, how much shall be saved?

The following does not pretend to be a theory of saving, but is suggestive of the complex nature of the saving-versus-consumption decision, to the extent that such a decision is made.[10]

A. The Anticipated Size and Shape of the Income Flow in the Absence of Income-earning Savings.

Most persons, if forced to consider the matter, have vague expectations concerning their income patterns through time. These expectations will vary with occupation (manufacturer, physician, civil servant, unskilled itinerant worker, etc.), the presence or absence of contract, and so on. The expectations will usually be rather fuzzy ("variable over a wide range", "rising modestly until 65 and then steady at a lower rate", "no hope of improvement", etc.), serving to instill in the subject a buoyant careless optimism, a penny-pinching cautiousness, or a deadening sense of futility, rather than to provide him with a precise series, useful as a basis for intertemporal financial manipulation. Vague as it is, this almost subjective feeling is the only personal-income projection an individual has for making manipulative decisions. It should be added that,despite the lessons of capital theory, much of a person's expectation will be influenced by past and present experience. For instance, the different backgrounds of migrant field hands versus sanitation workers will induce very different views of the future. While the actual size and shape of an income flow will affect the ease with which an individual can save, the act of saving

[10]More sophisticated contemporary theories of saving are, of course, those of James S. Duesenberry in his Income, Saving, and the Theory of Consumer Behavior (Harvard University Press, Cambridge, Mass., 1949) and Milton Friedman in his Theory of the Consumption Function (Princeton University Press, Princeton, N. J., 1957). The notions herein are inconsistent with neither, although, in their institutional context, they more closely approximate Duesenberry's ideas.

itself has other determinants.

B. Uncertainty and Saving -- The Precautionary Motive.

Uncertainty about the future is an ineradicable fact of economic life. While the predictive distribution of error may be narrowed in many operations, for the consumer uncertainty is a datum with which he must wrestle. Since we cannot extrapolate the thin line of income into the haze of time,and since life itself can spring many a costly surprise, prudence demands the accumulation of some liquid or near-liquid funds. The fact that savings accounts or government bonds offer interest is incidental. Some portion of the funds so incarcerated would be there, even at a negative rate.[11] In general, we can say that such savings are a positive function of uncertainty and prudence, and that their magnitude will not be influenced by the rate of interest.

C. The Desired Pattern of Income Flow.

In an age increasingly dedicated to the welfare state, retirement pensions, and unemployment relief, the likelihood of individual destitution becomes increasingly remote. Even so, contradictory pressures for early-versus-late consumption force an individual to reprogram his income, in the realization that the "ideal" and actual patterns are unlikely to coincide.

Among the pressures for consumption now, rather than later, we might list a number of factors:

1. Basic minimum physical needs. These pressures are, obviously, relatively slight in advanced societies.

2. Excess over (1) imposed by self-imposed standards. Here we consume for convenience (an automobile) or self-indulgence (steak versus hamburger).

3. Excess over (2) imposed by socially-imposed standards. The desire for status recognition need not be emphasized, although

[11]Demand deposits are not entirely to cover current transactions. The negative interest rate, in the form of an opportunity cost or service charge, surely testifies to the non-income earning inducements to save.

the distinction in practice between (2) and (3) is probably hard to draw. One might purchase a Mercedes-Benz because it is a status symbol, but, on the other hand, it is not inconceivable that one might honestly appreciate a subtle contour and superior workmanship.

4. A fourth distinction, cutting across these. Some durable items can be consumed over long periods of time (country real estate). One does not have to choose between consumption now and consumption later. Because of the long time span involved, there is no need to defer these purchases with a view to balancing the intertemporal flow of consumption.

There are, however, forces working in the opposite direction.

1. Specific cumulation objectives. Even in this age of massive credit, we cannot usually cover the expenses involved in durable consumer goods (mobile and immobile), foreign travel, children's education, etc., out of income concurrently with the outlay. Anticipation of these needs forces the reduction of earlier consumption.

2. Rationality. It is not without the realm of possibility that man's increasing education carries with it a commensurate increase in the prudent handling of his personal income.

3. Longevity. Perhaps one of the few assertions about intertemporal income choice, that can be made with certainty, is that people look with displeasure upon the prospect of a future <u>decline</u> in income. Since most contemporary retirement schemes involve such a decline, and since medical science is increasing longevity, it is only natural for people to make allowances for this by reducing early consumption.

4. Social pressures reducing current consumption. Parents, in giving their children the benefit of college education, to some extent are succumbing to the mores of our age. Similarly, we might add, the widespread interest in the stock market today seems to carry with it some of the elements of a fad. It is fashionable to have one's tame stockbroker, and stock is often purchased irrespective of the relative merits of alternative assets.

With the possible exception of (4), the financial reward for current abstention is <u>not</u> the determining factor in whether or not people save. Duesenberry, in his classic study, expressed skepticism concerning the classical role of interest rates in inducing saving:

> ...no very strong trend in long-term interest rates can be observed. That being the case, we cannot explain changes in saving on the basis of changes in the ratio of assets to income or on the basis of changes in the terms on which present income can be traded for future income. That does not mean that those factors cannot influence saving, it only means that during the period 1870-1930

they did not move enough actually to affect saving.[12]

While it is true that most forms of saving elicit interest payments, it does not necessarily follow that interest payments are made to induce people to save. It is more likely that interest payments perform the distributional function of attracting savings to one form of non-consumption rather than another. An interest-inelastic supply of savings with an interest-elastic demand for such funds can still produce a positive rate of interest and, indeed, such would be the explanation that would follow from our proffered analysis of the factors influencing saving-versus-consumption decisions. We might add that neither point made above -- neither the interest inelasticity of saving nor the purely distributional role of interest rates -- can be easily established empirically. This is largely due to the complex structure of interest rates, dividend payments, capital gains, risk premiums, tax advantages and maturity periods, which exists at any time, which cannot easily be unravelled by any statistical technique, and which defies attempts to identify that unique value called the rate of interest which can be correlated with changes in the rate of saving.

These considerations force us to question the commonly held Fisherian conception that people will save or lend up to the point where their marginal rate of time preference equals the interest rate. Since it is not clear what role interest-rate considerations play in consumption-versus-saving decisions, it is difficult to see how time preference can be meaningfully expressed by any interest within reason.[13] And if there is no such thing as the rate of interest, how are we to select the rate to

[12]James S. Duesenberry, Income, Saving , and the Theory of Consumer Behavior (Harvard University Press, Cambridge, Mass., 1949), p. 67.

[13]Undoubtedly rates far above market rates, e.g., 50 per cent, could influence savings behavior significantly, but it is hardly proper to base generalizations on extreme cases.

which marginal time preference should be equated?

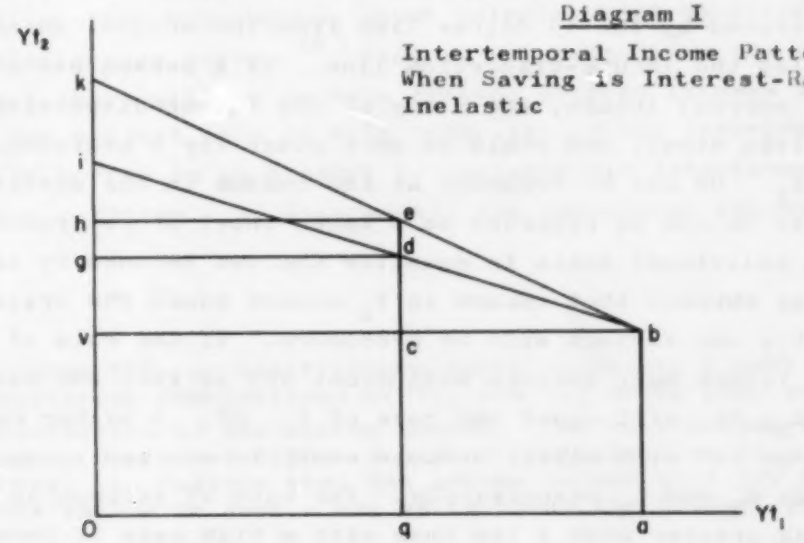
Diagramatic techniques elucidate some aspects of intertemporal preference, but are limited in their expository utility by many things, not the least of which is their two-dimensional character. According to the assumptions one makes, one can "prove" that interest rates have no effect on savings, have a perverse effect, or are positively correlated.

MODEL I. Interest-Inelastic Saving Behavior

Diagram I represents the case in which savings behavior is determined exogenously to the diagram and is not responsive to changes in the rate of interest. It is thus closest to our assessment of empirical conditions, to wit, that consumption is socially determined, and that savings are a residual available only after current demands are met. Income in $t_1$ is Oa, while income in $t_2$, in the absence of saving, is Ov. Ideally, we would like to represent Oa as current earned income, and Ov as retirement income, but two-dimensional analysis does not permit us to take into account the varying number of years over which these incomes will be earned. The individual, recognizing that income in $t_2$ will be less than income in $t_1$, and in addition desiring

Diagram I

Intertemporal Income Pattern When Saving is Interest-Rate Inelastic



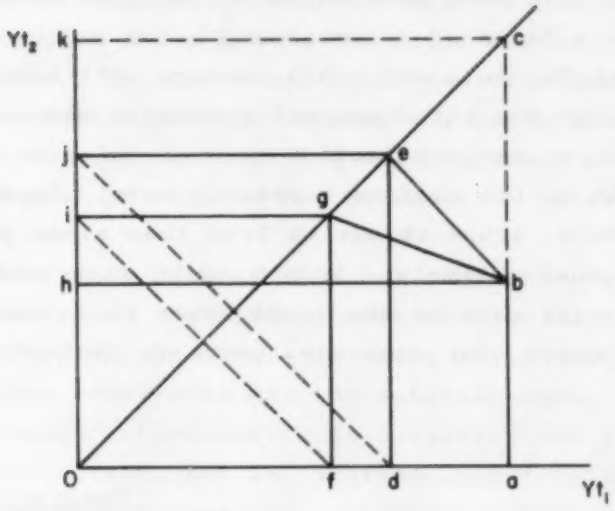
liquidity, will wish to save. His savings, aq, will be determined by the kind of considerations mentioned above; that is, not so much by what he would like to have in $t_2$, but more by complex, subjective pressures, most of which press for early consumption. Our saver will be happy to earn a higher interest rate on his savings in $t_1$, but largely because such premiums influence his net income to such a small degree that interest-induced changes in saving will be negligible. Thus his actual income in $t_2$ will be his expected income Ov (pension) plus the interest earned on aq. This interest is aq times the rate of interest; for instance, slope bi for bk. If $t_2$ were a "one-shot" period, instead, or an amalgamation of a number of periods, the savings principle aq could be added to income in $t_2$ to give the gross income for that year. On the other hand, aq could be regarded as a liquidity fund to meet contingencies in either period, in which case it would not be added to income in $t_2$.

MODEL II. Perverse Interest-Elastic Saving Behavior

Another possibility is illustrated in Diagram II, in which the income earner has a much clearer intertemporal picture. We have assumed, as one possibility, that the individual does not want to face a declining income in his retirement years. This is indicated by the 45 degree line from the origin, which might be called the income-dispersion line. If a person had a preference for current income, the slope of the income-dispersion line would be less steep, and would be more steep for a preference for income in $t_2$. Oa can be regarded as the income in the earning year(s), while Oh can be regarded as a lower level of retirement income. The individual seeks to equalize the two incomes by saving in $t_1$. It is obvious that income in $t_2$ cannot equal the original income in $t_1$, and savings will be necessary. If the rate of interest is low (slope bg), savings will equal af, so that the rate of income in $t_2$, Oi, will equal the rate of $t_1$, Of. A higher rate, (slope be) will elicit savings equal to ad, and incomes of Od and Oj in $t_1$ and $t_2$ respectively. The rate of savings is perverse, being greater with a low than with a high rate of interest. The

Diagram II

Perverse Saving Behavior




marginal rate of time preference, in this case, is represented by a series of 45 degree lines such as if and jd, and there is no necessary coincidence of these lines with the interest rate.

## MODEL III. Interest-Elastic Behavior

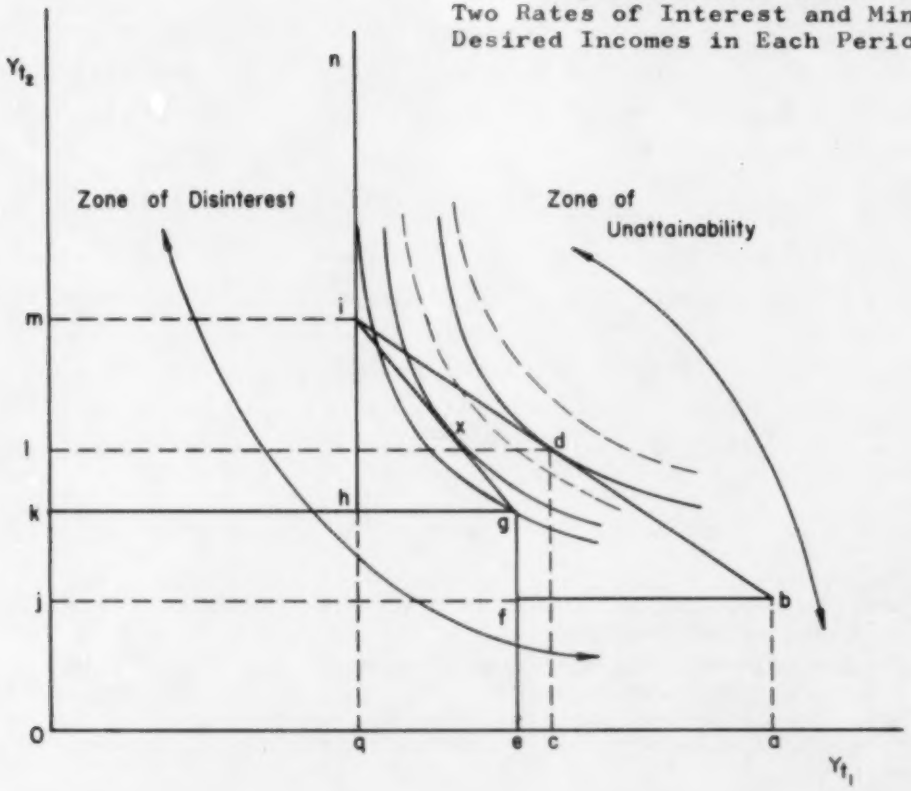
Still another hypothesis, about intertemporal behavior, makes use of indifference curves.[14] Diagram III recognizes the possibility that there will be certain minimum desired incomes in both periods, but subject only to this restraint -- the individual will lend and/or borrow in an attempt to maximize his intertemporal income-flow position. In this model, the individual receives an

[14] In diagram III, an indifference curve joins all points representing different combinations of $Y_{t_1}$ and $Y_{t_2}$ which give an equal total satisfaction to the income earner. The curves upward, and to the right, represent higher levels of satisfaction than the lower curves. It follows that the income earner will try to distribute his income in such a way as to touch the highest possible curve.

income Oe in $t_1$ and Ok in $t_2$. He is willing to save in each period, but sets a minimum consumption standard below which he will not go. He will not save more than eq in $t_1$, or more than kj in $t_2$. This establishes a "zone of disinterest" below and to the left of the perimeter nhgfb, into which his savings will not penetrate. His starting point for intertemporal financial manipulation is g. Slope gi is the maximum lending rate of interest he can attain, and slope ib is the minimum borrowing rate. In an imperfect capital market, slope ib may be less than slope gi, but this, of course, is most unlikely. If not, only gi is relevant, and the individual will save to the point where gi is tangent to an indifference curve; for instance, point x. But if slope ib is less

Diagram III

Intertemporal Income Choice with Two Rates of Interest and Minimum Desired Incomes in Each Period



than slope gi, the individual will maximize his intertemporal position by lending hg and then borrowing along ib, until a tangency with the highest attainable indifference curve at d is attained. The area above and to the right of the perimeter niba is unattainable. In this case, it is proper to say that the marginal rate of time preference equals a particular rate of interest. Whether or not a person will be a net borrower or lender will depend on the complex of interest rates and indifference curves.

It is clear that nothing that has been said, so far, leads us to a clear-cut and unequivocal measure of time preference. Only in the third of the models is there any relation between the rate of time preference and the interest rate. This rate of time-preference/interest-rate is certainly not any universally applicable market rate, but is, instead, a reflection of a particular individual's market opportunities. This gives us a policy clue which we will shortly exploit.

Individual behavior, with regard to switching income from one period to another, and consuming or not consuming in any period, is determined by many factors, some highly subjective, and there is no definitive way to assess the role of the interest rate. In the models where the interest rate was an important factor, these other considerations were held constant, and naturally the interest rate won, by default, as a measure of intertemporal income adjustment. Any given individual's reaction to a change in interest rates is unpredictable on an *a priori* basis. Individual and aggregate savings may rise, fall or be unaffected by such changes, and since income from saving constitutes only one of many determinants of the savings flow, any interest-induced changes are likely to be marginal. As we shall see, this does not mean that indices of time preference cannot be ascertained in some cases, but it does cast doubt on the unquestioned use of interest rates as discounting factors.

DECISION II. The Distribution of Savings Amongst Alternative Assets.

Out of a given current income, an individual ascertains the

desirable savings flow on varied and conflicting bases.[15] Given this flow, its allocation amongst alternative uses must be considered. In terms of liquidity, risk-and-return choices must be made among such possibilities as money hoards, demand deposits, savings deposits, insurance, pension plans, corporate shares and so on. The distribution will be made on a number of bases, some of which the individual already took into account in Decision I. Many conflicting demands will be made on this thin flow: liquidity for short-run transactions, liquidity to hedge against uncertainties, specific cumulative objectives, the need for semi-permanent flows upon retirement, and so on. It would be interesting to examine the factors involved in distributing savings among these alternatives, but such an endeavor would divert us from our central focus on intertemporal assessment.[16] We will instead invoke the working hypothesis that the saver distributes his funds amongst various alternatives on the basis of some predetermined design, but that, within each savings category, income possibilities play an important role. In other words, supposing that an investor feels it necessary to fill two distinct needs: (a) savings for liquidity; and (b) savings to augment retirement income. The interest rate will not alter the ratio of (a) to (b), but will affect the choice of alternatives within each category. Considering the liquidity portfolio, for instance, savings accounts,under present circumstances, are almost as liquid as demand deposits,

[15]Nowhere in this analysis are we asserting that the factors influencing Decision I need necessarily rise to the surface and take the form of conscious rationality. In many cases, one's savings may appear to be a mere residual after current obligations are met. But the level of such current obligations is, in part at least, a reflection of subconscious intertemporal preferences. Decision II is more likely to be fought out on the surface. As they first appear, savings are not committed in any way, and the individual is forced to consider their disposition quite openly.

[16]The determining factors are less likely to involve a heavy emphasis of subjective factors, and will more likely involve a tug of war between liquidity, risk and income prospects.

but the interest on savings accounts will induce the saver to keep as little as possible in demand deposits. Within the accumulation-for-retirement group, the saver will normally select, out of alternatives of equal risk, those which offer the highest return.

## APPLICATION OF THIS THEORY OF SAVING-DECISION MAKING TO CORPORATE DISCOUNTING PROCEDURES

Let us apply this approach to our central concern, intertemporal preferences as they affect corporate decision making. Purchasers of corporate securities have in mind one of three objectives:

(1) Some may seek profits from short-run price movements. The interests of this group, transitory as it is, should have little influence on a corporation's long-run planning.

(2) A second group seeks long-run accumulations in equity value, usually from capital gains.

(3) A third group has a primary interest in a corporation's flow of detachable income, usually in the form of dividends.

The interest of group (1) in any given corporation is transitory only, since its basis is usually the short-term capital gains to be extracted from rapid changes in the market value of shares. Long-term development projects are of interest for this group only to the extent that they generate a temporary interest in a security from which capital-gains profits can be extracted. Conversely, the corporation should pay little attention to this group in setting company policy and can certainly ignore its time preference.

However, those with greater loyalty to a given issue are implicitly expressing a measurable time preference which policy makers can exploit. Take, for instance, group (2), the "long-term capital gainers". More frequently than not, they hold securities, not for the sake of dividends, but for accumulation, and intend at some terminal date to liquidate these holdings for transfer to assets giving larger current returns. To the extent that it buys such securities, this group has a definite time preference for

future income, which might be called an "accumulation preference". The purpose of discounting cash flows in this case is not to overcome people's resistance to deferring income, but rather to ensure that an acceptable rate of accumulation takes place. So for any given security, the accumulation factor R, reflecting "accumulation" preference, could be found from the rate of growth of the share's value calculated over a period of time sufficiently long to soften the effect of extraneous underlying influences.[17] In principle, the company must select projects which will yield a rate of growth in share value which, over the long run, will equal R.[18] If projects are selected in such a way that $R_r$ (realized rate of growth) is greater than R, then additional lower ranking projects should be included in the portfolio to bring $R_r$ and R into equality. Conversely, if $R_r$ is less than R, then lower ranking projects should be dropped. If the rate of discount d equalled R and only projects which had a positive or zero net worth were included, the over-all $R_r$ would tend to rise. This would more than satisfy the stockholders, and would lead to ever increasing difficulty in finding acceptable projects, since, in the long run, R would also rise. Accordingly, the marginal prin-

[17] A more accurate method would be as follows: Divide all current stockholders of more than six months' "loyalty" into convenient holding-longevity groups (e.g., A, 6 to 18 months; B, 18 to 30 months; and C, 30 to 42 months), calculate the security's accumulation coefficient for each group, from its average holding period to the present (e.g., for A this would be 12 months, for B, 24 months, and so on), and then find R for the stockholders as a whole, from an average weighted by the security holdings of each group. It should be noted that the longer the average period of holding for the stockholders as a whole, the greater would be the validity of R as a discount factor.

[18] At this point in the argument, one is troubled by the influence on share values of factors external to the firm; for instance, the current popular enthusiasm for stock ownership. In the short run, these can accelerate R, but short-run influences should be removed statistically. If such a change in social patterns of investment becomes permanent, it should increase R to some degree, but it is difficult to ascertain a priori and ex ante by how much.

ciple of just satisfying stockholder expectations, no more and no less, should apply. This leads to the somewhat paradoxical situation that, if d=R, it will be necessary to accept projects which have negative present values, in order to maintain $R=R_r$. This paradox could be resolved by an iterative technique of selecting a value for d less than R, such that $R=R_r$.

In situation (3), in which stockholders look forward to a high, relatively stable dividend, the appropriate rate of discount will be determined quite differently, and will reflect neither a "time preference" nor an "accumulation preference". Typically, this group represents retired persons who seek a high stable income, and who are, in the extreme case, not interested in capital growth. In some cases, which we will not consider, they may even be prepared to consume capital at a rate sufficient to maintain a desired level of consumption. Their income-flow preference pattern is relatively stable, and accordingly, they would be unlikely to lend or to borrow, except in emergency, since either practice would reduce income during some part of the flow period. Since no intertemporal income transfers can be induced, no discrete measure of time preference can be calculated. For lending, it tends towards infinity, and, for borrowing, towards zero.[19]

As before, in determining the appropriate rate of discount to apply to projects, the corporation must assess this group's intertemporal preference pattern, which could be characterized as follows: the stockholders demand (at least) a high and constant dividend flow, but, of course, would be willing to accept an increasing rate of flow, provided that the early returns were not reduced. Let us consider just the limiting case, in which dividend flow is constant. Since no interest rate can reflect this group's time preference, and since the group seeks an unvarying rate of income flow, should the discount factor equal zero? In

[19]The borrowing rate would be positive, but meaningless. The individual would borrow at rates below the current lending rate, of course.

other words, should there be no rate of discount at all applied to cash flows? This would be true only in the case in which the reinvestment of depreciation reserves was sufficient to maintain the income flow. Such is not likely to be the case. Even in an economy which exhibited no economic growth, business would have to introduce new technology to counteract the diminishing returns resulting from the growing scarcity of resources.[20] In a growing economy experiencing technological development, even those companies not wishing to grow will be forced by competition to introduce new machinery. Unless the machinery is capital-saving, or neutral in this respect, it could not be financed out of depreciation allowances. Accordingly, in many cases, the capital stock needed to maintain a constant dividend flow will have to increase. If the required annual rate of new investment is q, then q is the rate of discount to be applied. But it should be applied only to that part of the net return to be used for reinvestment, not to the entire amount. Applying it to the profits to be distributed would be meaningless, since the stockholders demand an unvarying absolute sum annually. To them, dividends in year n carry the same weight as dividends in year 1, and no intertemporal switching is desired except as indicated in the meaningless case in footnote 19. On the other hand, a time preference exists for the portion of the funds to be reinvested, since, if a project did not allow the accumulation factor q to be garnered, future dividends would necessarily have to be reduced.

## THE ARGUMENT RESTATED

(1) We have been concerned here with a rather limited problem: How will a corporation assess income flows occurring in future periods of time?

[20] An exception might be in certain extractive industries where rising raw material prices offset the increased cost of production. But this introduces the problematical element of price changes, which it is best to avoid in this context.

(2) The conventional approach is to discount these future flows at some rate of interest supposed to represent people's intertemporal income preference. The widely accepted theoretical justification for this follows Fisher, and is somewhat as follows: If, in order to induce a person to give up the consumption of x dollars, an interest payment equal to y is needed, then y must represent that person's assessment of income in year(s) n versus income in year 1.

(3) We disagree with the Fisher position, arguing that, although in some cases a rise in the interest rate may lead to an increase in savings, the determinants of the rate of saving are more obscure and fundamental. It is difficult to believe that it has been established that the interest rate plays a role, in savings-versus-consumption decisions, sufficient to justify its use as a measure of time preference. Indeed, we demonstrated that in some cases it is clear that the interest rate does not measure time preference.

(4) Neverthless, some "shadow rate of interest" should be used to assess future cash flows, but we believe the theoretical basis to be different, more closely approximating that of Dorfman.

(5) The discount factor to be applied in assessing corporate income flows must reflect the preferences of the corporate owners, and will be unique to each corporation. The discount factor becomes, then, an index of performance to judge whether or not these preferences are being met; and, as argued above, it should not necessarily be applied to all segments of the cash flow.

* * *

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# THE ECONOMIC ANALYSIS OF MILITARY EQUIPMENT REPLACEMENT

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A matter of extreme importance today is the titanic struggle going on between two conflicting ideologies, in all spheres of activity. Of more immediate interest, as far as this paper is concerned, is the race for economic and scientific supremacy. There is a growing realization that excellence in both economic and scientific fields is essential for survival, but there are sharp differences of opinion as to what should be done to achieve a high rate of development in each field.

While the United States has inherited, from past generations, a position of dominance in the economic and technical spheres, it is only in recent years that Americans have come to appreciate the importance of scientific achievement. This was suddenly imposed upon the nation's consciousness with the advent of the atom bomb, and has been kept alive by continuing spectacular scientific developments. But the staggering financial burden placed on this country, as a result of its present role as leader of one of the contending factions, has brought home forcibly and suddenly the fact that there is a limit to the wealth which we once tended to take for granted. For perhaps the first time in our history, we are faced with the urgent necessity for making the best use of our resources.

National security, particularly military preparedness, depends in large part upon scientific developments; and this dependence has resulted in a highly dynamic state of technology and science, and a rapid rate of invention. A concomitant feature of a rapid rate of invention is a high rate of obsolescence, attended by tremendous cost. The rate of progress is far outstripping the rate at which the economy is able to grow and provide the increased funds necessary for such purposes as national defense. There is

a limit to the funds that can be diverted for such purposes without reducing our level of living and perhaps seriously retarding future economic growth. Hence it is becoming imperative to devise methods of using these funds to the greatest possible advantage.

This paper is concerned with the economic analysis of invention applied to military preparedness. The emphasis on this work has resulted in continuous improvements to weapons systems, which tend to become increasingly more complicated and more expensive. It is assumed that it is possible to devise objective methods of decision making based on economic factors, when planning for systems improvements, and that it is possible to obtain a real advantage in this approach, viz., a greater return from defense expenditures. Spending on weapons systems results in a capital investment in equipment which serves a useful but not an economic purpose. The subject is related to capital-expenditure analysis as made in business and industry, although there are some significantly different features in military expenditures. The attempt to apply economic analysis in this field is likely to result in confusion, as to the aims, and outright hostility on the grounds that this is not primarily an economic problem. The justification for this approach therefore warrants careful consideration.

The evaluation of equipment-replacement policies considered herein has this much in common with the usual industrial analysis, viz., that the problem largely arises because of the factor of obsolescence. If anything, technological innovation occurs at a greater rate in the development of military weapons. In both cases, the objective is the same, i.e., to make the most effective use of capital. There are, however, certain basic differences in environmental factors that require different treatment. For instance, the effect of obsolescence in industry is primarily on operating costs and secondarily on operating performance, whereas the reverse of this is true in military systems. In the latter case, improved performance is the main objective sought, and in many cases this results in increased operating costs. Techniques of equipment analysis have been developed primarily for industrial

purposes. The method that is discussed in this paper for the analysis of military equipment is based on the work of Terborgh[1] and was selected for this purpose because it is one of the few methods that takes improvement in performance into consideration as one factor in equipment-replacement analysis. It therefore seems to be the most adaptable method for use in weapons-systems analysis.

## THE RATIONALE OF ECONOMIC EVALUATION

This study is limited to the investigation of the possibility of applying economic criteria to equipment-replacement practices with reference to weapons systems. This in no way suggests that economic considerations should be the only criteria used,but it does suggest that there is a need for considering economic factors, particularly in view of the fact that these have received but scant consideration to date. It is not intended in any way to affect decisions made with regard to the research and development of new weapons, with the exception that it will be pointed out that this method of analysis might be useful in giving guidance to the research effort. It is assumed that the work of research and development is carried on independently of decisions made to adopt a new weapon, produce it in quantity, and incorporate it in existing weapons systems.

For a frame of reference, let it be assumed that a new ballistic air-to-air missile has been developed which is superior in various ways to the one in present use. It is intended to be used by the air arm of the Navy for task-force defense. It is desired to determine if the present missile should be replaced. The following discussion is shortened by omitting all of Terborgh's arguments, and by using, without explanation, a few of his short-cut methods which seem to be applicable to this particular analysis. Following Terborgh's terminology, the present missile is referred

[1]George Terborgh, Dynamic Equipment Policy (McGraw-Hill Book Company, Inc., New York, 1949).

to as the defender and the new missile is called the challenger. It is assumed that the challenger has known characteristics, that a weapons-system evaluation has been made to determine its operating advantages, and that it is the best challenger presently available. Further improvements can be made, and it is highly likely that further development work will be carried on, whether or not it is made operational. It is also assumed that the defender will be scrapped if it is replaced.

The economic criterion used is the comparison of the adverse minimum costs of both missiles. The adverse minimum cost is defined as the lowest time-adjusted average of capital cost and operating inferiority cost (including changes in serviceability and cost of operations) obtainable from the equipment. A short-cut method of computing the adverse minimum of the defender is to compute the next year's cost advantage of the challenger. In the case of the challenger, a short-cut method of computing the adverse minimum is by means of the formula

$$\text{Adverse Minimum} = \sqrt{2cg} + \frac{ic - g}{2},$$

where c is the initial cost, g is the annual inferiority gradient, and i is the rate of interest to be charged for the use of capital. The annual inferiority gradient arises from the fact that the challenger will almost immediately be subject to obsolescence. It is estimated by dividing the defender's adverse minimum by the present age of the defender.

Obsolescence is sometimes defined as the technological displacement of equipment. It affects both operating performance and operating costs. The problem is to relate the two in comparable terms, usually dollars. In this analysis, the problem was met by assuming that an increase in performance resulting from the improvement of equipment could be matched by an increase in the amount of the present physical facilities. This makes it possible to assign

a dollar value to improved performance. The assumption cannot be made if the new missile can do a job impossible of performance by the old missile (this is not unduly restrictive considering that most of the effort is devoted to improving existing systems). It is obvious at this point that relatively small improvements in performance, requiring large amounts of money, cannot be justified on economic grounds. A simplified example should help to clarify the conceptions involved. Let it be assumed that a new missile has been developed which will increase the effectiveness of task-force defense by 20%. No change would be required in the other system components.

Adverse Minimum of Present Missile

Since the old missiles would be scrapped, there is no capital cost involved. If it is assumed that no additional personnel or facilities are required to service the new missile, there would be no difference in annual operating costs. The only change would be an increase in the effectiveness of the system due to the use of an improved missile. Next year's change in effectiveness is calculated as follows: The present system, with a given amount of facilities, has a capacity to perform a certain function. Let it be assumed that the annual cost of maintaining this capacity is $40 million. If the present missile is replaced, the system will have an increased capacity due to the increase in system effectiveness. In order to match this increase in capacity with the present system, an additional expenditure of $8 million (20% of $40 million) a year would be required. Therefore, the adverse minimum of the defender is $8 million.

Adverse Minimum of New Missile

This is computed from the formula previously given. Let i be taken arbitrarily as 2%, since the discussion of a suitable choice of i is beyond the scope of this paper. (The factor of i is not very critical in this determination for a reasonable range of possible values of i. Thus for i=5%, the revised adverse

minimum is equal to $8,673,000, representing an increase of only about 4%.) Assume that to replace the present missiles with a like amount of new missiles would cost $24,500,000. This is c. To find g, assume that the present missile has been operational for 5 years. Then g = $8,000,000 / 5 = $1,600,000.

$$\text{Adverse Minimum} = \sqrt{2 \times \$24{,}500{,}000 \times \$1{,}600{,}000} + \frac{.02 \times \$24{,}500{,}000 - \$1{,}600{,}000}{2}$$

$$= \$8{,}335{,}000$$

There is such a small difference between the two adverse minimums that it is a matter of indifference, economically, how the improvement is obtained.

Interpretation of Analysis

It should be clear that this analysis is not concerned with the determination of the necessity for increasing system effectiveness. The need for improvement is a separate non-economic matter. Given the need, the problem is to determine how best to satisfy the requirements. There should be no reason for economic considerations to impair system effectiveness. When the somewhat haphazard way of developing new weapons, and continually modifying them, is considered, better planning for systems development should not only save considerable sums of money, but should result in better systems. And to the extent that systems improvements are made for the purpose of incorporating new developments, without regard to the necessity for making improvements as disclosed by intelligence reports, the use of economic criteria is all the more important.

It is not intended that this analysis procedure should result in a decision rule, since a decision cannot be made on this basis alone. Rather, it is a useful guide in planning for systems changes.

It is not suggested that increased effectiveness should be obtained by expanding present facilities, in the event that an analysis discloses that the defender's adverse minimum is lower than that of the challenger. Instead, this should be interpreted as showing the desirability of lowering the challenger's adverse minimum. It would be helpful to consider the ratio of the defender's adverse minimum to that of the challenger. Cost improvements would be brought about by continually striving to increase this ratio, rather than by being overly concerned with the requirement that the challenger's cost should be at least as small as the defender's cost.

Because of the rapid rate of invention, with a resulting rapid rate of system obsolescence, and the long period of time required to make changes operational, a policy of freezing systems at a high level of capacity is of questionable value. Although this matter is not of immediate interest so far as this paper is concerned, the dynamic state of weapons technology seems to imply an important requirement for flexibility, with a possible sacrifice of some capacity. Greater consideration needs to be given to the factor of capacity, particularly with regard to imbalance among components. The determination of ordering quantities is one area where a consideration of the matter of balance would be helpful. Clearly, excessive quantities of some components are an economic waste and otherwise serve no useful purpose, assuming that the proper balance is determinable.

This paper has discussed the use of economic analysis for a particular problem, viz., the desirability of making a change in a specific system component, whereas there are probably broader applications. For example, by considering all possible components that affect system performance, the most economic method of improving performance could be determined. Thus, it may be determined that an increase in the speed of aircraft has a lesser effect on task-force defense than a proportional increase in the range of missles. This together with a consideration of the cost of using better aircraft, versus the cost of using better missiles, might indicate clearly that one method of change is superior to

others. Similarly, an analysis of the best method of using weapons, and the improvement of operating tactics, would be another possibility. Broader analyses made along these and similar lines would also be useful in giving some indication as to where the emphasis on research should be placed. Such analyses would admittedly become quite complicated, but the results would be much superior to those of intuitive decision-making processes.

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## 1961 NOMINATIONS FOR POLICY BOARD
The Engineering Economy Division
American Society for Engineering Education

The following members have been nominated for election to the Policy Board of the Division:

Robert M. Eastman, University of Missouri
David V. Heebink, Stanford University
Jean C. Hempstead, U. S. Air Force Academy
Edward C. Keachie, University of California
Markwick K. Smith, American Telephone & Telegraph Co.
Robley Winfrey, U. S. Bureau of Public Roads

The election is to be held in June at the ASEE Annual Meeting, at the University of Kentucky.

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BOOK REVIEW

A Review of: THE STAGES OF ECONOMIC GROWTH
A Non-Communist Manifesto
By W. W. Rostow
Cambridge University Press, New York, 1960
179 pp. Cloth ed. $3.75; paper ed. $1.45.

By: Joel B. Dirlam, Consultant
Development Board
Amman, Jordan

Written by an economic historian who has served as consultant on foreign aid and military strategy for several administrations, this is an ambitious book. It presents what purports to be a novel theory of recent economic development. But it does more than this, particularly in the closing chapters; it presents a program for stabilizing United States-Soviet relations, inquires into the spiritual future of a mass-consumption society, and tries to find a political alternative to Communism, for underdeveloped countries. Exhortations and admonitions to the average citizen in the Western World, and to leaders everywhere, come thick and fast, once the preliminary sketch of the process of development is gotten out of the way.

This reviewer is too modest to attempt to assess the entirety of the discussion in Rostow's book; to do so would take him into fields where he can pretend no competence. A peremptory judgment might perhaps dismiss the book on parallel grounds. But Rostow cannot stop to duplicate Toynbee; he pleads the urgency of his concern with current interactions between economic development and international politics. In the circumstances, it seems both fair and reasonable to limit comments largely to the growth theory itself, upon which depend the subsequent policy pronouncements. Since much of Rostow's terminology has already caught the public fancy, and crept into journalistic treatments of development (thus testifying to its contemporaneity, if nothing more), an outline here can be mercifully brief.

Modern economic societies, in the Rostow system, pass through

five stages. The first Rostow calls "traditional", where science and technology are pre-Newtonian, a high proportion of resources is devoted to agriculture, and social structure is hierarchical. There is a ceiling on output-per-head which can never be exceeded, imposed by resources and static production functions. Rostow would lump together, as "traditional" societies, the thriving cities of the Decapolis, with their baths, temples, theatres, shops and aquaducts, and the tribes of nomadic Bedouin who pasture their flocks today in the ruins of Gerasa. In the next stage, society develops preconditions for a take-off into growth. The preconditions are social and political, as well as technological. Nationalism, as a political movement, whether in colonial areas or in Britain itself, has been essential to provision of the political and social setting in which agriculture makes surplus income available for industry, the state creates the social capital, and progressive business leaders replace landlords as the elite. And Colonialism may stimulate nationalistic groups to break with traditional agricultural organization.

During the crucial third stage, the "take-off", growth becomes the "normal condition" of a society. The rate of growth of net investment (gross investment less depreciation) definitely outstrips the rate of population increase, and raises per-capita income. Tentative take-off dates are 1783-1802 for Great Britain, 1843-1860 for the Unites States, and 1890-1914 for Russia. Two conditions, other than per-capita-income increase, must be present during the take-off. At least one substantial "manufacturing" sector -- defined broadly to include "timber in Sweden, meat in Australia, dairy products in Denmark" -- must develop. Secondly, there is necessary "the existence or quick emergence of a political, social and institutional framework which exploits the impulses to expansion in the modern sector and the potential external economy effects of the take-off and gives to growth an on-going character" (p. 39). (Though an outgrowth of lectures to English undergraduates, the book often reads like an uncorrected dictated draft.)

The fourth stage is the "drive to maturity", when society

"effectively" applies the range of available technology to "the bulk of its resources". Leading sectors in this stage will be defined by the nature of resource endowments. As an example, the Russian take-off occurred when grain prices rose and it became profitable to build a railway net and establish a coal-and-iron complex from the proceeds of wheat exports. The Communist reorganization shifted the momentum of the take-off to its own peculiar goals during the drive to maturity. Rostow frankly faces the difficulties of defining, as mature, both the French economy prior to World War I, and the Japanese economy prior to World War II, since in both economies agriculture was technically backward and labor-intensive.

In the drive to maturity, powerful economies are liable to be diverted to war. Following this phase, they move to a fifth stage, that of high mass-consumption, achieved first by the United States in the 1920s.

It is on the basis of these carefully distinguished stages that Rostow arrives at his program for the nations today in the "transitional" stage. These societies are similar in many ways to those which enjoyed a take-off a century ago. They must allocate substantial amounts of investment to social capital, to increasing agricultural output, and earning foreign exchange. Entrepreneurs must be shifted from trade and money-lending to industry. And nationalism must be harnessed to the public good. But there are differences which set modern underdeveloped nations apart from the earlier ones: a rapid rate of population increase, urban unemployment, and the political distractions of the cold war.

To move to the take-off in the face of these modern handicaps, three policies must be simultaneously adopted. First, technology must be brought to bear more effectively, particularly in agriculture. Secondly, external assistance must be enlarged and stabilized. Some $4 billion more in annual aid (from all nations) is required if all undeveloped areas (presumably not including Communist China) are to move into sustained growth, although realistic figures, says Rostow, drawing on a survey made

by himself and Millikan, would be somewhat lower. In many areas, external capital can not be absorbed on such a lavish scale. Most important, the elite of the underdeveloped nations must take an active role in checking population growth and in repressing wasteful manifestations of nationalism. Communism, by providing at one and the same time a modern state organization and a progressive elite, provides an easy solution to present-day handicaps to preconditioning. But Communism is unnecessary if a substantial and enterprising commercial middle class exists, and if there is an adequate political consensus among political leaders. Hence, Rostow calls it a "disease" of the transitional societies. He sees Russia as technically ready for high mass-consumption, but "... Communism is likely to wither in the age of high mass-consumption ..."(p. 133). Against their own political interests, the Communists must somehow be persuaded that undeveloped nations can move to a well-established take-off within the orbit of the democratic world, if there is not to be nuclear war when China and the other undeveloped nations drive to maturity.

Rostow frequently resorts to verbal shorthand or symbolism. The reader is sometimes expected to react tropismatically, rather than to think. In Rostowese, for instance, "Malthusianism" somewhat incongruously stands for a rapid rate of increase of population, "Buddenbrooks dynamic" for greater enjoyment of the aesthetic side of life.

What might seem to be complex, and, to the specialist, ambiguous, historical developments are treated in a cavalier fashion. As Rostow views it, the nationalism that shifted Germany from a traditional to an industrial society was sparked by "... -- the Junkers and the men of the East, more than the men of trade and the liberals of the West"(p. 27). This, with a similar remark two pages later on, constitutes the entirety of the analysis of German nationalism; it ignores the split of the Conservatives under Bismarck, and the liberals' attempt to goad Frederick William IV to centralization. The history of Japanese and Russian nationalism is set forth in similar capsule form. Rostow preferred " ... articulating new ideas briefly and simply

to an intelligent non-professional audience" (p. X). Professionals or even semi-professionals, however, are likely to find themselves resorting frequently to the encyclopaedia or other sources to check generalizations, whose persuasive power is sometimes sapped by critical examination. That this will be the response is, of course, a calculated risk faced by all writers of manifestoes.

What of the internal logic of the theory of stages itself? If it is to hold water, the first requisite is that the stages should embody a minimum element of inevitability, in both the direction of development and the sequence of stages. Rostow is too good a historian to insist that his stages can, in actuality, be sharply defined. His table of "take-off" dates is in fact so qualified by lengthy footnotes as to raise serious questions about the usefulness of the tabular arrangement. Dating the beginning and end of the other "stages" presents difficulties. As Rostow takes pains to point out, some countries omit some stages. Canada hurried from the take-off to mass consumption without passing through the drive to maturity. In Australia, the take-off and high mass-consumption coincided. There are prolonged periods that cannot be readily assigned to any of the growth stages, such as the 1929-1939 world-wide depression, and the preceding decade of stagnation in Europe. United States prosperity, since the end of World War II, has been sparked by continuous military spending, including outer-space exploration: this particular phenomenon does not fit into the five-stage model.

Will future change (or "growth") follow the patterns discerned by Rostow in the 1783-1950 epoch? For one thing, as the Middle East stagnates and one African state after another leaps to independence and economic chaos, it requires a strong effort of the will to see nationalism as generating favorable preconditions to the "take-off". Something else will have to replace it -- perhaps (after many years of trial and error), close cooperation with United Nations administrators. Communism may be a "disease of the transition" to Rostow, but, to be realistic, we must recognize that, at least in watered-down form, it does not appear so to a large part of the progressive elite in undeveloped areas. It is

doubtful whether democracy-plus-private-enterprise could devise a workable program for Cuba, Yugoslavia, Venezuela, Greece, Iraq, Indonesia, and India.

In another respect Rostow's theory seems not merely inadequate, but outmoded. His military-strategy and foreign-policy proposals are fully alive to the stalemate imposed by atomic weapons. But his economic history, with its Newtonian watershed, never quite catches up to contemporary technology, with nuclear reactors, computers and satellites.

The Pill will radically change population trends in areas where the future now looks bleak -- or sterilization will accomplish the same result. Whatever lies ahead for both developed and underdeveloped nations will be upon us swiftly and seems unlikely to recapitulate the past. Stages -- no matter how defined -- will be telescoped. While it is true that the generalization that "all history is the history of class struggles" is unacceptable today, the substitute that "history is a succession of stages from traditional society to that of high mass consumption" is not much more appealing.

Hence, although Rostow will -- and deserves to be -- widely read and quoted, his major contribution will probably continue to be the coining of some apt terms -- the "take-off", and the "drive to maturity". Taken in isolation, there is nothing novel in his program for underdeveloped areas -- though it is unobjectionable. The immediate problems of development -- inculcation of an atmosphere conducive to long-run business planning, breaking out of the vicious circle of subsistence farming, over-grazing and degradation of vegetation, and the reconciliation of efficiency with saving foreign exchange -- can only be solved on the spot, with patient and continued efforts, applied largely on an _ad hoc_ basis. As propaganda, Rostow's book may be helpful: somewhere, a minister reading it may be impelled to allocate more funds to an agricultural research program, or to in-service management training. But _The Stages of Economic Growth_ is not unique in this respect.

Though Rostow fails to achieve a grand synthesis, he must be given high marks for effort. By attempting to integrate

political-social-and-economic-tendencies trends into an engine for prediction and programming, he requires his readers to try to perform the same feat, if they are to accept, or reasonably dissent from, his doctrine and his prescriptions. Industrial engineers and business economists, even if they remain sceptical of the degree of precision of his growth patterns, may very well be induced to adapt Rostow's analysis, or parts of it, to firms or industries; useful insights will doubtless be derived from uncovering both parallels and differences.

• • •

## INTEREST TABLES

An Extension of Available Interest Tables, a 42-page reprint, is still available; in addition to the tables, it includes an introduction and examples of the use of the tables, which were prepared by Professor Ralph O. Swalm at Syracuse University. Price $1 (25% discount on purchases of more than 25).

## THE 1962 SUMMER SYMPOSIUM

The next Symposium is now being planned to precede the 1962 Annual Meeting of the American Society for Engineering Education, scheduled for June 18th-22nd at the United States Air Force Academy.

THE ENGINEERING ECONOMIST will be happy to pass on, to members of the Planning Committee, any communications from our readers containing suggestions for the agenda. Get them in early; this is long-range planning. Announcements and news of the Symposium will appear in later issues.

THE ENGINEERING ECONOMIST
Stevens Institute of Technology
Hoboken, New Jersey

1962
SYMPOSIUM

The suggestions below were submitted by

NAME _____

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_____

## THE 1959 SUMMER SYMPOSIUM PAPERS

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As most of our readers know, these papers and discussions relate to the subject of "Planning and Justifying Capital Expenditures". They were presented at the 1959 Summer Symposium (Summer School) of the Engineering Economy Division of the American Society for Engineering Education and the Engineering Economy Research Committee of the American Institute of Industrial Engineers. They are addressed to students and practitioners in the field of capital investment, and cover five major topics:

(1) Capital Budgeting and Project Justification.
(2) Post Auditing
(3) Estimation of Working Capital Requirements for Long-range Planning.
(4) Effects of Taxes on Investment Decisions.
(5) Evaluating Uncertainty.

The papers are by George Terborgh, V.J. Reilly, F.H. Zoeller, R.P. Connelly, J.B. Weaver, W.J. Murphy, P.W. Smith, R.B. Maffei, and R.B. Fetter; discussions are by D.G. Bodenhorn, G.J. Matchett, Colin Park, E.L. Grant, F.A. Gitzendanner, and W.B. Hirschmann.

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ANNUAL MEETING
ENGINEERING ECONOMY DIVISION
American Society for Engineering Education

Wednesday & Thursday, June 28-29, 1961
University of Kentucky
Lexington, Kentucky
(ASEE meets June 26, 1961 - June 30, 1961)

THEME: COMPARISON OF PROJECT JUSTIFICATION IN FOREIGN AND DOMESTIC OPERATIONS

- • -

MINUTES OF ANNUAL MEETING, Purdue University, June 21, 1960

The meeting was called to order by F. A. Gitzendanner, Chairman, at 12:50 p.m. The following agenda was presented:

Reading of the Minutes of the 1959 Annual Meeting
Presentation of the Chairman's Annual Report
Election of Officers
Summer Symposium
Division Membership
Relationship with American Association of Cost Engineers
The Engineering Economist
Program for 1961 Meetings

The minutes of the 1959 annual meeting were distributed by the Secretary. Three errors in the affiliation of those in attendance were noted on the attendance list. It was moved and seconded that the 1959 minutes be approved as corrected. The motion carried unanimously.

The Chairman distributed copies of the Division Annual Report, which he had prepared in accordance with ASEE policy.

The report of the Nominating Committee was presented by R.M. Eastman, Committee Chairman. The following were nominated to the Policy Board for a two-year term, from 1960 to 1962:

Billy E. Goetz
Eugene L. Grant
Anatole R. Gruehr
Arthur Lesser, Jr.
John H. Norton
James B. Weaver

The following were nominated as officers of the Engineering Economy Division:

Ralph Swalm, Secretary
G.J. Matchett, Vice-Chairman
N.N. Barish, Chairman

It was moved and seconded that the nominations be accepted. The

motion was passed unanimously. It was pointed out that as retiring chairman, F.A. Gitzendanner automatically becomes a member of the ASEE Council for a two-year term, replacing Anatole R. Gruehr, who has served a two-year term in this capacity. There followed a discussion to the effect that nominations should be publicized in advance. It was pointed out that in 1958 a motion was passed that "the Nominating Committee report should be publicized prior to the meeting through some such medium as The Engineering Economist". It was moved by Mark Smith that the Nominating Committee should be appointed well in advance of the 1961 meetings and that the nominees for the Policy Board be made known among the membership in advance of the meeting. The motion was seconded and carried unanimously.

The next topic on the agenda concerned the timing of the next Summer Symposium. It was agreed that we should not consider holding a Symposium at the University of Kentucky in 1961. The issue became one of holding a Symposium at the Air Force Academy Meeting in Colorado Springs in 1962, or at the University of Pennsylvania in Philadelphia in 1963. To get the issue before the group, a motion was made and seconded that the next Symposium should be held in Philadelphia in 1963. The main argument advanced for this location was that the area is highly industrialized. In opposition, it was pointed out that since the last Symposium was in Pittsburgh, the next one should be in a different section of the country, and that a three-year interval between such sessions was long enough. A vote was taken on the motion and it was overwhelmingly defeated. It was moved and seconded that the Chairman should appoint a committee which, with the Policy Board, should be empowered to make a decision as to when the next Symposium should be held. It was pointed out that the decision should be made at an early date. It was understood that the Industrial Engineering Division would like to consider another summer school in 1962 if the Engineering Economy Division did not hold a Symposium. If the decision was made to hold a Symposium in 1962, it was suggested a program committee be appointed in the fall (1960).

The Chairman raised the question of Division membership. He pointed out that new ASEE members with an interest in Engineering Economy should be invited to join the Division, and that new Division members should be sent a letter or notice by the Secretary welcoming them to the Division and informing them of The Engineering Economist and other Division activities. The retiring Secretary stated that he had written each new Division member, informing him of the Division publication and welcoming him to the Division. It was noted that many members of the Industrial Engineering Division who list Engineering Economy as a field of interest are not enrolled in the Engineering Economy Division. It was suggested that the Chairman should find out from Secretary Collins the reason for their not being listed.

The Chairman stated that ASEE has asked its membership to explore ways of cooperating with other organizations. He stated that the American Association of Cost Engineers has expressed an

interest in keeping our organizations informed regarding "matters of our mutual interests". It was moved and seconded that the Chairman appoint a committee to explore possibilities of cooperation between our Division and AACE. The motion was passed unanimously. It was suggested that since some of our members belong to AACE, it would be helpful to have some of these individuals on the committee.

The status of The Engineering Economist was discussed by A. Lesser, Jr., Editor. He stated that the subscription list seems to have stabilized in a definite circulation pattern, with a number of foreign subscriptions (10%). The mailing list was exchanged with the Harvard Business Review. G.J. Matchett stated that notices had been sent to the HBR list, and that by the end of the summer about 5000 notices would have been mailed to the members of the Controllers Institute. Lesser reported that the Symposium Papers were going well and would yield a profit.

Possible topics for the 1961 program were discussed. The general ASEE theme is to be "Engineers in World Affairs". Some time was spent on the idea of providing an international slant for the 1961 Division meetings. Topics suggested included: Engineering Economy in Underdeveloped Countries; Productivity Teams; Making Inquiry of the International Bank and State Department Regarding any Engineering Economy Activities; Differences in Company Practices in Project Justification, between Foreign and Domestic Branches of a Business; Educational Exchange. Alternative suggestions included: Organizing within a Company for Decision Making; Obsolescence; Report by Grant and Others Who Have Been Abroad Recently,on the Status of Engineering Economy in Other Countries.

The meeting was adjourned at 1:55 p.m.

Respectfully submitted,
G.J. Matchett, Secretary
Engineering Economy Division, ASEE

BUSINESS MEETING ATTENDANCE
June 21, 1960

C.A. Anderson, North Carolina State
A.R. Burgess, Texas A & M
H.A. Cowles, Iowa State
R.M. Eastman, University of Missouri
T. Elrod, University of Houston
R.S. Gay, Virginia Polytechnic
F.A. Gitzendanner, Standard Oil (Ind.)
A.R. Gruehr, Brooklyn Polytechnic
J.C. Hempstead, U.S.A.F. Academy
R.M. LaForge, University of Tennessee
O.J. Sizelove, Newark College of Engineering
R. Winfrey, U.S. Department of Public Roads
A. Lesser, Jr., Stevens Institute of Technology
G.J. Matchett, Illinois Institute of Technology
B. Mitchell, University of Dayton
W.R. Moore, Iowa State
G.E. Mullin, Jr., General Electric
J.H. Norton, du Pont, Inc.
M.K. Smith, AT&T
E.H. Weinwurm, DePaul University

BOOK REVIEW

A Review of: ENGINEERING ECONOMY
By William T. Morris
Richard D. Irwin, Inc., Homewood, Ill.
1960 506 pp. $10.50

By: John H. Norton
Industrial Marketing Analyst
Development Department
E. I. du Pont de Nemours & Co., Inc.

"You can't tell a book by its cover" is an old saying, but a good one to apply to William T. Morris' new text. Titled simply "Engineering Economy", the book, from an exterior view, might easily pass for just another addition to the growing library of texts on this subject. One is hardly prepared, therefore, for the pleasant surprise that comes on glancing at the Table of Contents and finding chapter titles such as: "A Review of Probability Theory", "Prediction and Judgment", "Decisions Under Uncertainty", "Game Theory", and "Simulated Decision Making". Fortunately, the text for these chapters, as well as that for most of the other twenty, lives up to the expectations aroused by a reading of the Preface. Here, the author promises to treat engineering economy "within the somewhat larger context of the analysis of management decisions". The author fulfills this promise, and, in so doing, contributes a noteworthy text -- one which blazes a new trail in the literature of engineering economy.

The author's approach is to bring to the attention of the student "ideas coming from Operations Research, Management Science, and Decision Theory", as well as to present "nearly all of the ideas which are traditionally included in Engineering Economy". It is because he meets the first objective so well that the whole book is commended. The treatment of the "traditional" material, contained largely in the first nine chapters, actually excites little interest. As material for a one-quarter course for third-year students (as used by the author at Ohio State), it may be adequate. However, a more comprehensive text, such as Grant's

Principles of Engineering Economy, seems much preferred for those who can afford more time. Morris' first discussion of depreciation, for example, covers just two pages. It thereby does not find room even for a mention of the sum-of-digits method. This omission is taken care of by a further discussion of depreciation in Chapter 8 ("Taxes"), but the total coverage is not apt to provide the engineer student with a sufficiently clear concept of this important subject, nor of management's responsibilities in making depreciation-policy decisions. Unfortunately, in Morris' text, it is the accountant who is presented as the one who establishes depreciation policy.

Similar criticism might be levied on the book for the abbreviated treatment given to other subjects -- interest, for example. However, these are petty criticisms. The book does not claim to be a comprehensive text in the methodology of decision making in such problem areas as machine replacement, and should not be judged on this basis. In fairness to the new approach taken, the book should be judged on the value of the new material which comprises well over one-half of its pages.

The author demonstrates almost immediately that this book on engineering economy is concerned with a broad spectrum of decision making. By page 12 he has introduced the concept of the decision matrix and described the three basic types of decisions with which the book is concerned: decisions under (assumed) certainty, decisions under risk, and decisions under uncertainty. A fourth category, "decisions under ignorance", is mentioned, but rightfully brushed aside as being unworthy of professional attention.

It is in the context of describing various types of decisions under certainty that Morris brings forth the "traditional" aspects of engineering economy. In this category are included such topics as: replacement policy; selection of analysis criteria; effects of taxes, depreciation-accounting methods, and interest; selection of alternates; development and screening of data; and the making of estimates and predictions.

Starting with Chapter 10, "A Review of Probability Theory", Morris lays the foundation for detailed discussions of decision

making under risk and uncertainty. Tackling decisions under risk first, the author presents a typical hypothetical problem of this type, encountered in manufacturing. With this as a framework of reference, he then describes four alternative "principles of choice", by which a decision could be reached: the principles of expectation, most probable future, expectation-variation, and aspiration level. No effort is made to persuade the reader that any principle has more merit than any other. While this has the happy result of keeping the author out of the midst of a major controversy, it has the unhappy effect of giving little direction to the student.

To correct this situation, but still with care to avoid taking sides, Morris then presents, in Chapter 13, a number of examples of decisions under risk, together with "some suggestions which hopefully will lead the reader to ponder and form his own opinions" regarding principles of choice. The examples are also intended to suggest methods of approaching the vast array of problems which a firm meets in dealing with factors largely outside of its control.

This is a worthy objective, but the effort seems to fall somewhat short of the goal. This is due more to lack of quantity than to lack of quality. The author simply tries to cover too much territory in one chapter -- covering problems such as economic lot size, insurance decisions, waiting lines, maintenance policy, inspection sampling, quality control, and equipment investment, all in the space of 32 pages.

To complete his review of decisions under risk, the author presents one short chapter each on inventory policy, bidding policy, and purchasing policy, as representing typical decisions the firm must make in dealing with suppliers, customers, and competitors. This material is well presented and contains many valuable notions regarding strategies and decisions in these problem areas. There is a danger, however, that the student may be misled regarding the importance of some of the assumptions used. In presenting an example of an inventory problem, for example, it is noted that one of the relevant considerations is the future demand for the item to be stocked. After finding, by appropriate statistical

techniques, that there are no identifiable effects influencing demand, the decision maker, in the example, concludes that future demand will be much like that of past demand. This, of course, is a major decision in itself, and it sets the course of any future analysis which attempts to determine the optimal inventory level. Perhaps, in a statistical sense, no better assumption can be made. Nevertheless, it seems appropriate to call attention more forcefully to the importance of this type of assumption, which is, unfortunately, often glossed over almost casually.

The author does an excellent job of covering current activities regarding decisions under uncertainty, in the space of three chapters: (1) showing why certain classes of problems must be viewed as decisions under uncertainty; (2) presenting some interesting examples of such decisions, together with suggested analysis techniques; and (3), reviewing briefly the highlights of game theory as applied to certain types of decisions under uncertainty.

The remaining chapters (20-26) deal with topics which do not fit neatly into the classification of decision making under certainty, risk, or uncertainty. These are presented as material suitable for a "one-quarter elective course for seniors or graduate students", and cover the following loosely related subjects: statistical decision making, diversification, decisions under pressure, the measurement of values and probabilities, economics of automation, simulated decision making, and how decisions are made.

The main value of these concluding chapters is to provide an overview of current research activities in decision making, including such controversial topics as the usefulness of subjective probability and business games. The very nature of this research prevents the author from drawing any hard and fast conclusions. He does, however, effectively present many of the problems encountered and make liberal reference to a large bibliography of recent work.

In presenting engineering economy as an integral part of the broad spectrum of management decisions, the book keeps the student from falling into the convenient and easy rut of thinking that

engineering economy is merely the application of some pat formula in the selection or replacement of machinery, or in the screening of alternates whose futures can be assumed to be known. However, in touching on such a wide variety of problems, the book cannot seem to avoid two shortcomings. One, that of being too "thin" in spots, can be corrected by the student through the expedient of doing the suggested outside reading, and making use of the bibliography.

The other shortcoming is more serious. It is the lack of a central theme to unify the many well-presented individual ideas. The author did not look for such a theme, perhaps because he visualized the book as the text for three separate courses. However, many instructors may want to use it as the text for a straight-through course for third- or fourth-year students. Those instructors will have to produce their own theme. They might use, for this purpose, a hypothetical new product, following it through its life span from research laboratory to initial commercialization, thence through expansion of facilities, and eventually to obsolescence and retirement, noting that management decisions change basically from those under uncertainty to those under risk, and finally to those under assumed certainty; and noting, also, that the role played by engineering economy changes correspondingly. A fully developed example, along these or similar lines, would help tremendously in bridging the gaps which now separate the various sections of the book.

Despite these shortcomings, Professor Morris' text deserves an over-all rating of "excellent". It is believed that all subscribers to the Engineering Economist will find it worthy of careful study.

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Return to the Secretary, W. Leighton Collins, University of Illinois, Urbana, Ill.

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For Industrial Membership Form
See THE ENGINEERING ECONOMIST, Vol. 6, No. 2.

## BOOK REVIEW

A Review of: INDUSTRIAL ESTATES*
By William Bredo
The Free Press of Glencoe, Illinois
240 pp. $6.00

By: William J. Roth, Jr., Division Manager
Engelhard Hanovia, Inc.

The problems of fulfilling the building needs for manufacturing and industrial companies, whether in the city or in the suburban areas, is not new. The appearance of another book on this subject would not be unusual. However, since the purpose of this study was to bring together the experiences of industrial developers, in a number of different countries throughout the world, in an endeavor to show how such projects aid in the development of small and middle-sized enterprises, the book is a noteworthy contribution in the field of industrial development.

The title of this book, "Industrial Estates", is a good one. But it is unfortunate that there are so many synonyms in use, such as: "planned industrial districts","industrial parks", "organized industrial districts", "industrial centers", "industrial terminals", "industrial buildings", ad infinitum. All of these terms come under the general heading of industrial real estate and all have to do with fulfilling the space requirements for industrial enterprises. For the purpose of this review, and in respect for this name -- coined by the author -- I will use the term "industrial estates" wherever it can be properly applied.

For those who are seeking information about the specific techniques necessary to plan and/or manage industrial estates, this book will not be rewarding. This is not meant to be a criticism of the study, but rather a caution to all those who might

*A publication of the International Industrial Development Center of Stanford Research Institute, Menlo Park, California.

venture into this field. Because of the many factors involved in planning an industrial estate, an individual would need a library of books in the mechanical, electrical, civil and industrial engineering fields, as well as information on financing and real estate law, in order to have sufficient information to solve the many problems involved.

The author has supplied interesting information on the broad aspects of sponsorship, organizational structure, preproject planning, site selection, factory planning and financial management, all of which should be informative to sponsors of industrial estates.

Dr. Bredo most wisely has devoted space to tell of some of the disadvantages and limitations of industrial estates, and, also, the dangers and pitfalls of which sponsors should be wary. Although he has done well in condensing this topic, here again it must be realized that books could be written on the subject. Dr. Bredo further states that "most of the apparent disadvantages can be overcome by proper planning", and this is most certainly true. However, the planners must also perform a most exacting job, because any errors made in the initial planning will cause the sponsors to be plagued for years with such problems as industrial pollution, high operating costs, incompatible manufacturing companies, dissatisfied employers and employees, lawsuits and countersuits, bankruptcies, etc., all of which will tend gradually to downgrade the industrial estate and ultimately lead to the creation of an industrial slum. Also, poor planning will obviously prevent the development of the full economic potential of the property involved.

The descriptions of various industrial estates throughout the world, as outlined by the author, will prove to be interesting reading for practicing executives in the industrial real estate field. In particular, the rental prices, and concessions granted, point up the extent to which countries are going to assist in the development of industry. A few examples follow:

(1) In India, buildings from 2,000 to 10,000 square feet will be erected to rent for 24 cents per square foot per year, for the first 3 years, and 48 cents per square foot per year thereafter.

(2) In Haslow, England, a factory in excess of 20,000 square feet will be built and rented for 77 cents per square foot per year on a 21 year lease.

(3) In Mexico, tax exemptions up to 25 years have been granted.

(4) In Puerto Rico, the Economic Development Administration, in addition to furnishing the usual services and facilities, has organized an Industrial Service Department that provides training and placement of managerial personnel, a marketing-research service and an industrial-engineering service.

One aspect of industrial development, which has not been included in Dr. Bredo's work but which should be kept in mind by sponsors and developers, is the conversion of existing buildings or plants into industrial estates. In a dynamic industrial society, factors will arise that will cause companies to abandon or relocate their operations. Such incidences are unfortunate but must be accepted as one of the realities of a competitive industrial economy. When this happens to a big operation, it presents a major problem to the community. The hope of finding another enterprise of comparable size, to take over the facilities, is wishful thinking. What happens in many instances is that the property and buildings are sold off piecemeal to different companies, which many times have incompatible operations. Here is where the creation of an industrial estate (whose job it would be to lease the properties to small and medium-sized enterprises and to control the use of the properties by protective covenants in its lease arrangements) would be the best over-all answer for the welfare of the community, and would, as well, provide a way to achieve the full economic potential of the property.

As an example of the conversion of existing buildings to a modern industrial estate, the experience of our East Newark Industrial Center* is somewhat unique. This property is believed

*These properties, owned by Engelhard Hanovia, Inc., consist of 30 various-sized buildings, totaling 1,300,000 square feet, where electric power, process steam, building heating, elevator service, maintenance and engineering assistance can be provided by the owners.

to be the largest known group of industrial buildings that originally was designed for a single enterprise, but which has been successfully converted into an industrial estate, providing a complete package of building services and facilities for various manufacturing enterprises. In 1934, when the original owners of the property moved to the southern part of the United States, seeking cheap labor, the community was in a depressed state, with several thousand unemployed workers. Now, in 1960, the buildings are filled with 40 different, but compatible, manufacturing enterprises, employing approximately 4,000 people. The development of this industrial estate, with selected diversified industry, in addition to being profitable to the owners and helpful to industrialists, will also insure the community against ever again becoming a depressed area.

One of the important aspects of any successful enterprise is its management. The operation of industrial estates is no exception. In his book Dr. Bredo has touched on this subject in the chapter on "Sponsorship and Organizational Structure". Since the success or failure of the industrial estate will depend upon the effectiveness of its management, the importance of this subject must be realized and considerable thought given to it during the planning stage. Too often we see the organization pattern grow and develop haphazardly, under the pressure of circumstances, instead of being a result of the application of known management principles. Sponsors of industrial estates should know the operating problems incidental to an industrial estate, and be prepared to design the management structure in accordance with sound principles of industrial management.

• • •

# Economics of Machine Selection and Replacement

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Prepared by
Ralph O. Swalm, Professor
Department of Industrial Engineering
Syracuse University

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